

# **Airborne Monitoring Of Air Quality Using Cost-Efficient Small Aircraft Combined with State-Of-The-Art Sensor Systems**

by

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**Traditional approach:**

**Large aircraft**

**19" boxes in racks**

**substantial modifications  
to aircraft**



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# TECHNOLOGICAL DEVELOPMENT

**Mainframe computer → PC**

**Manually operated systems → Microprocessor controlled systems**

**Complex, heavy navigation systems (nav/attitude) → GPS**

**Metal airframes → composite airframes**

**Big, noisy, dirty aircraft engines → small, quiet, clean engines**

**“Traditional” survey/research aircraft → SERA**

**SERA - Small Environmental Research Aircraft**



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# SERA

- Small Environmental Research Aircraft -

A new and exciting tool for environmental  
monitoring and research



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# SERAs

**ARA's Grob G109B**



**NOAA's Long-EZ**



**NOAA/SDSU's SkyArrow**



**MetAir's Dimona**



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## Simple vs. unsophisticated

- Despite their “simple look”, these aircraft are not simple tools, but highly sophisticated instruments for environmental monitoring.
- “Simple” is to be strongly distinguished from “unsophisticated.”
- **Indeed, it is the sophistication of the technology that allows the simplicity of operation.**



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# SERA Instrumentation



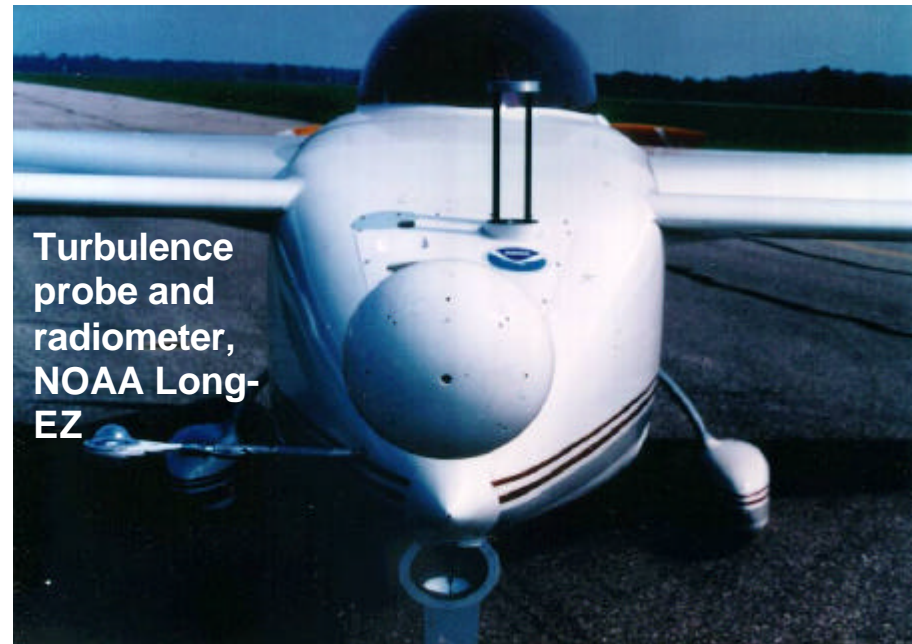
Instrumentation pod  
ARA Grob G109B



Instrumentation pod  
MetAir Dimona



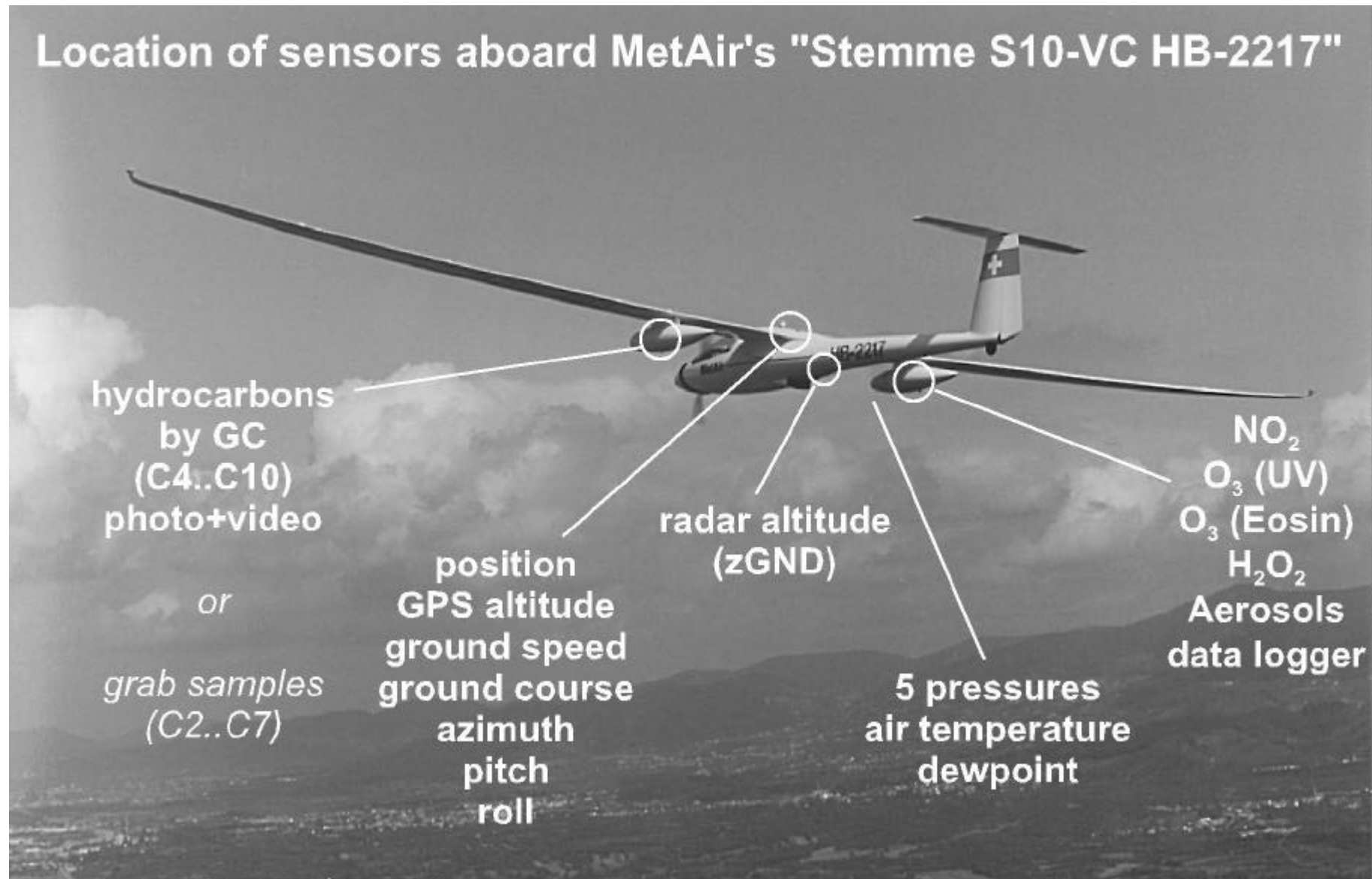
K-Band radar  
NOAA Long-EZ



Turbulence  
probe and  
radiometer,  
NOAA Long-  
EZ



## Location of sensors aboard MetAir's "Stemme S10-VC HB-2217"



# MetAir Eco-Dimona



**Airmotec gaschromatograph**



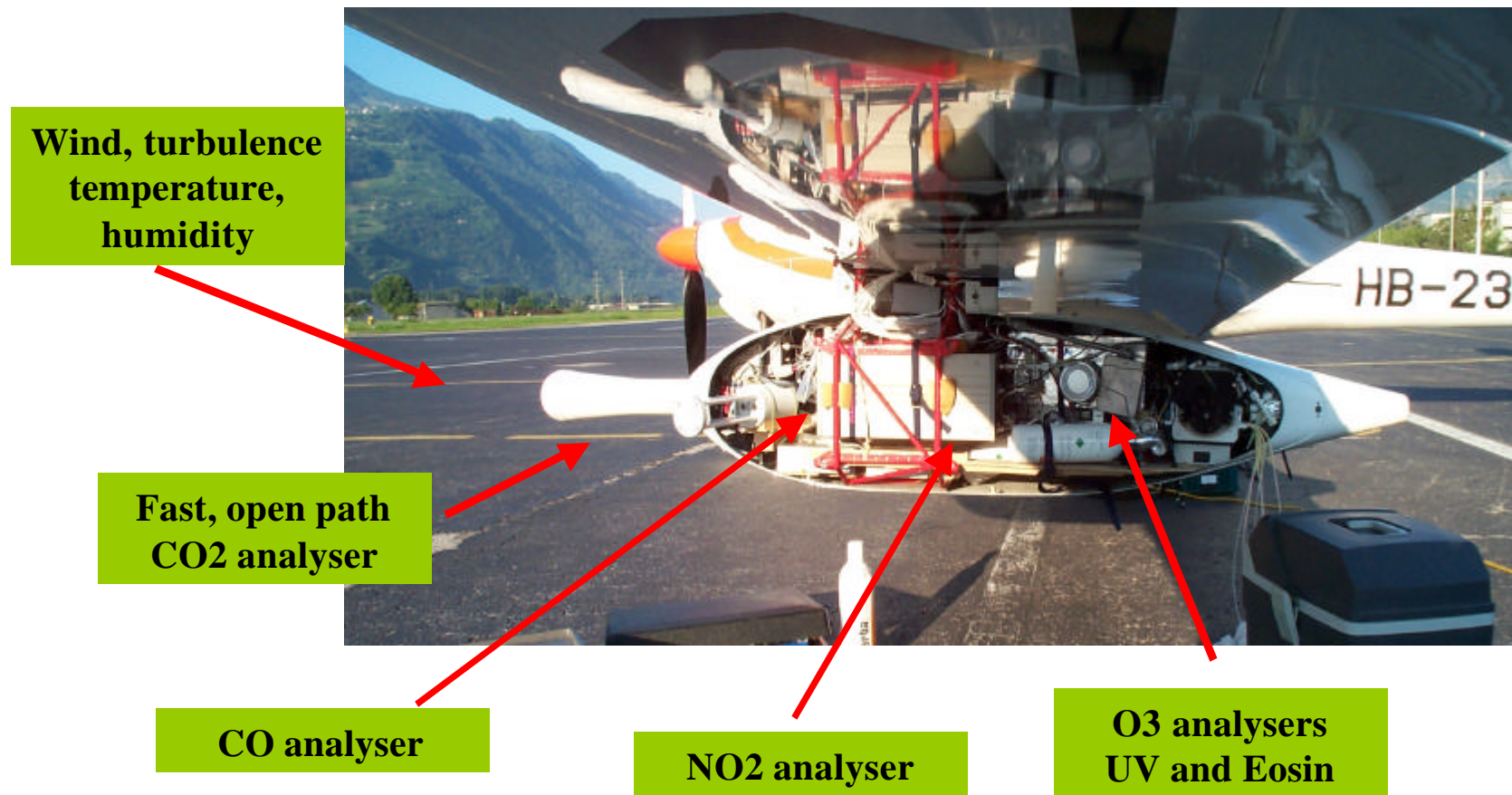
**Real-time data in cockpit**



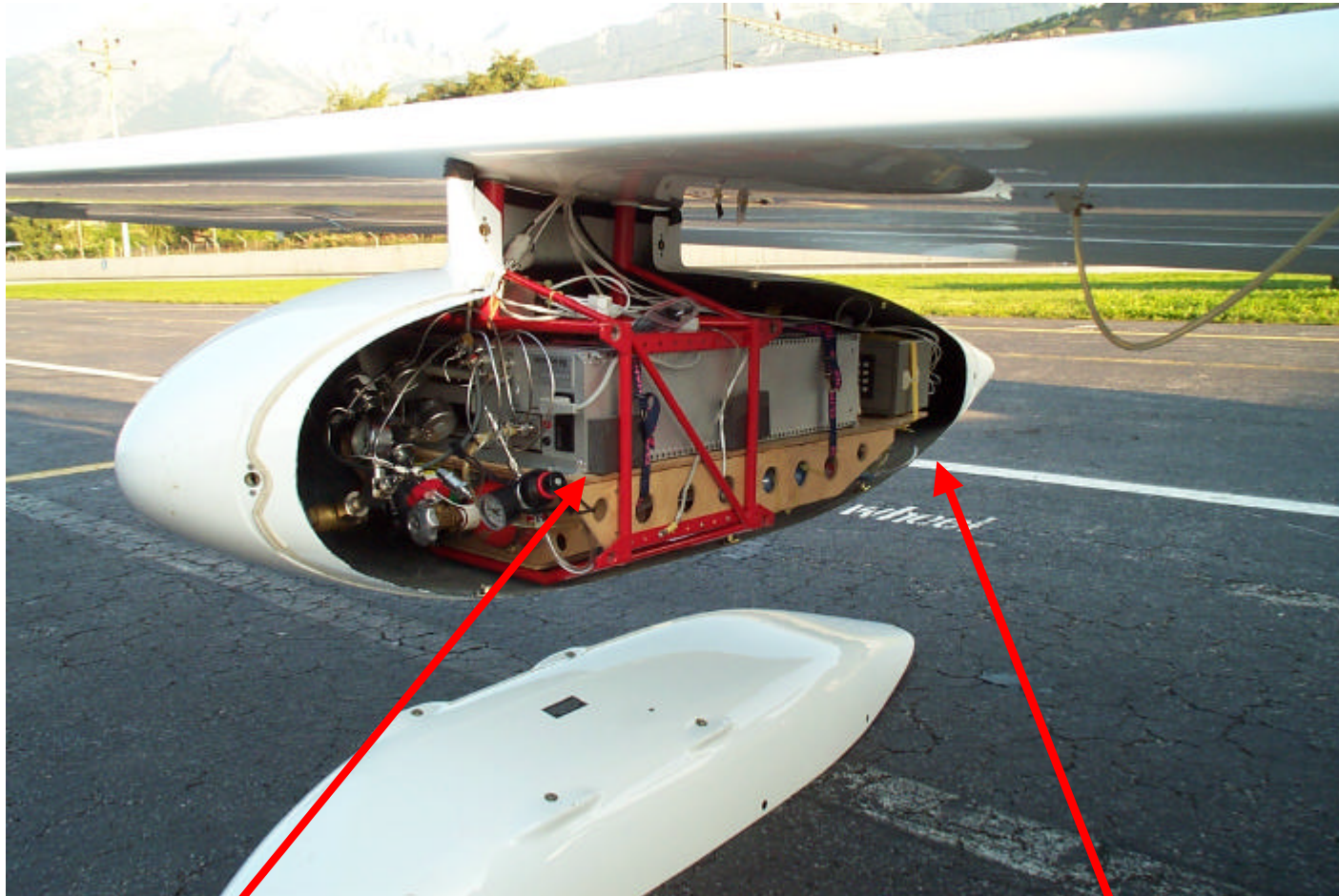
**19" rack**

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# MetAir Eco-Dimona



# MetAir Eco-Dimona



**MetAir/Airmotec gaschromatograph**

**LiCor 6251 CO2 analyser**

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**VOC species measured by the**  
**MetAir / Airmotec Gas-Chromatograph**  
**on-board the MetAir Dimona/Stemme S10**

|   |                             |
|---|-----------------------------|
| i-B u t a n                                 | i-O c t a n                 |
| n - B u t a n                               | n - H e p t a n             |
| tr-B u t e n                                | M e C h                     |
| c i s - B u t e n                           | T o l u o l                 |
| i-P e n t a n                               | 2 + 4 - M e H e p t a n     |
| A c e t o n                                 | 3 - M e H e p t a n         |
| n - P e n t a n + 2 - M e - 1 - P e n t e n | n - O c t a n               |
| I s o p r e n + t r - 2 - P e n t e n       | E t h y l b e n z o l       |
| c i 2 - 2 - P e n t e n                     | m - / p - X y l o l         |
| 2 - M e - 2 - B u t e n                     | o - X y l o l               |
| 2 2 - D M B                                 | N o n a n                   |
| C y c l o p e n t a n + 2 3 - D M B         | C u m o l                   |
| 2 - M e - P e n t a n                       | a - P i n e n               |
| 3 - M e - P e n t a n                       | P r o b y l b e n z o l     |
| n - H e x a n                               | m - / p - E t h T o l u o l |
| M e C p + 2 4 - D M P                       | 1 3 5 - T M B               |
| B e n z o l                                 | o - E t h T o l u o l       |
| C y c l o h e x a n                         | 1 2 4 - T M B               |
| 2 - M e H e x a n + 2 3 - D M P             | D e c a n                   |
| 3 - M e H e x a n                           | 1 2 3 - T M B               |



... obtaining  
near-source  
observations...

... and near-surface  
observations.





... obtaining  
observations in  
sensitive areas

... and complex  
terrain.

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... with minimal  
logistics support

... and minimal  
environmental impact.

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# **A FEW EXAMPLES**

**ARA, MetAir and NOAA are working closely together  
on the further development of the SERA concept.**

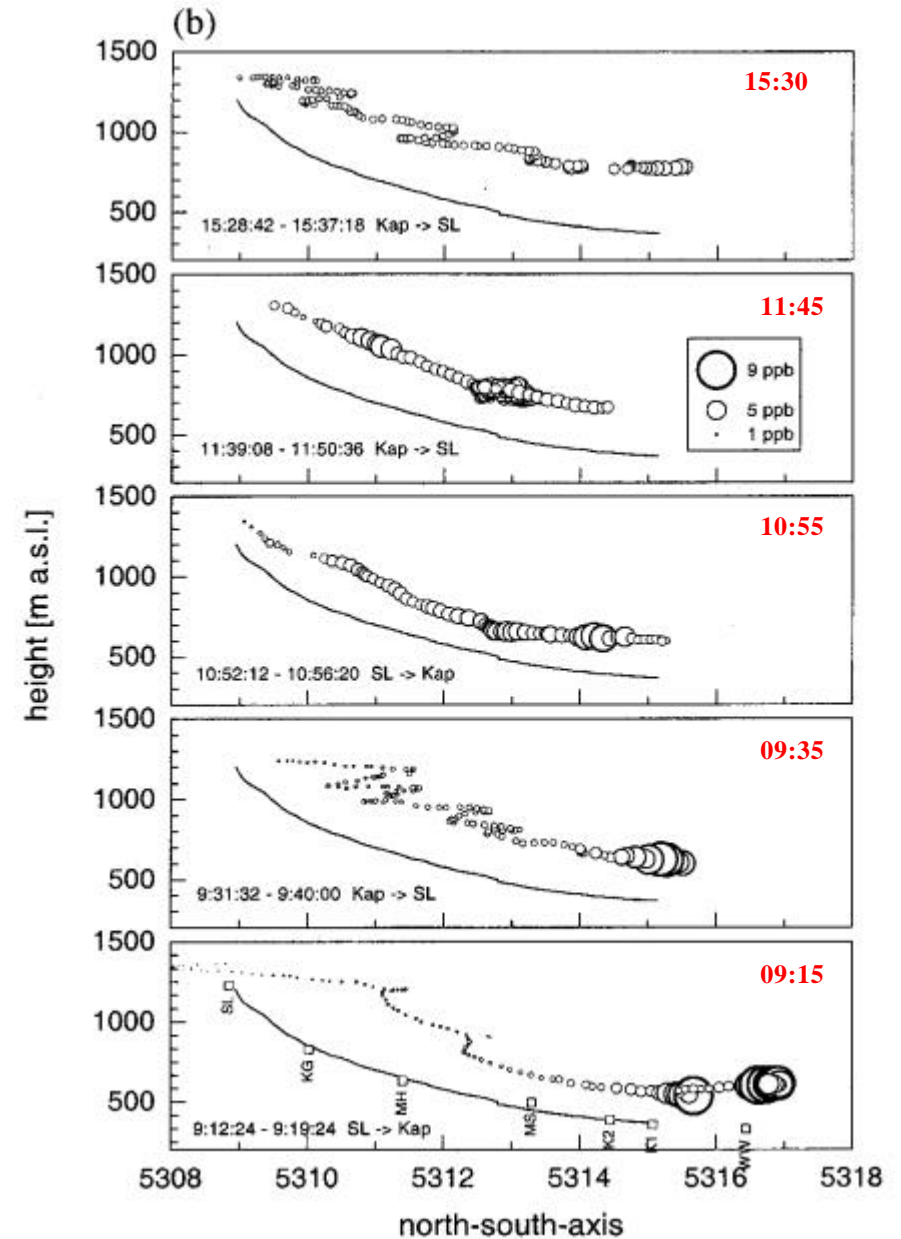
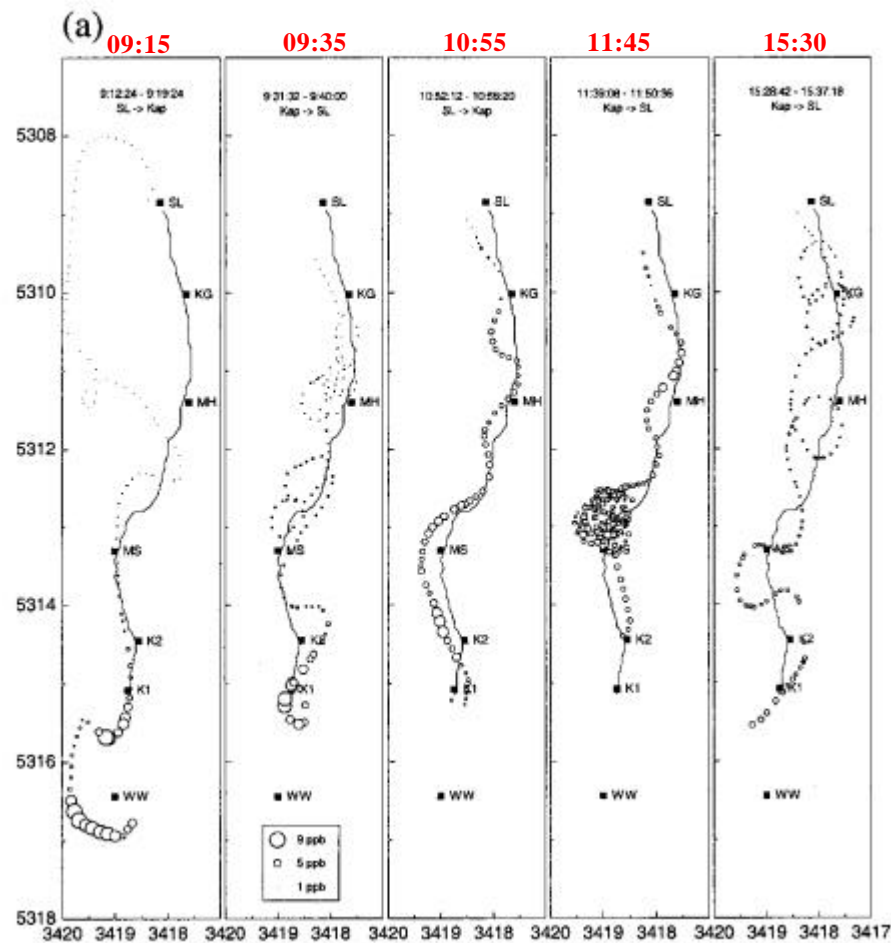
**ARA and NOAA are the leaders in atmospheric  
and remote sensing applications**

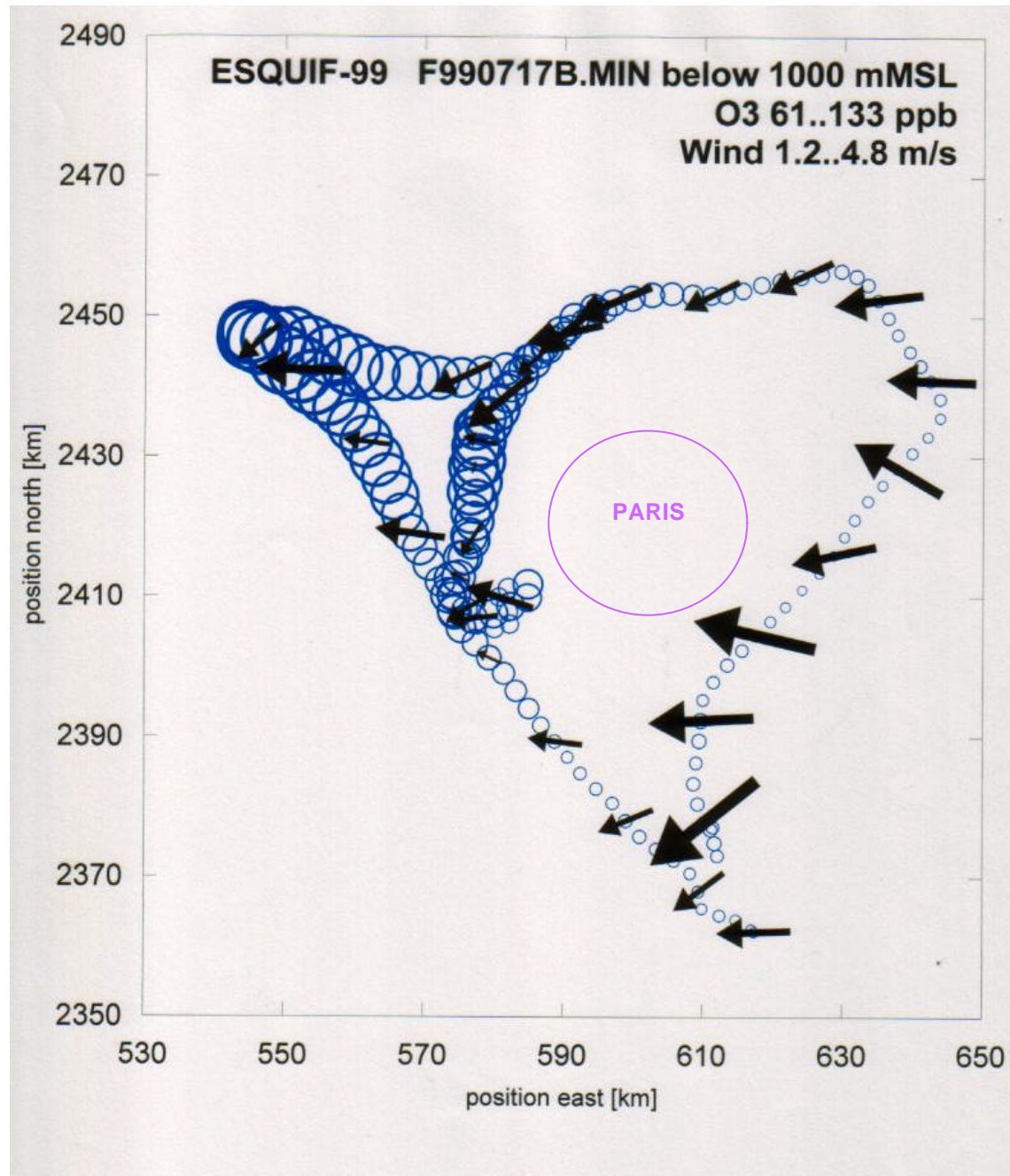
**MetAir is the leader in air quality / air pollution applications  
(therefore the examples are from MetAir's activities)**



# NO<sub>2</sub> concentrations along a valley in the Black Forest/Germany

From: Pätz et al., 2000: JGR 105, 1563-1583





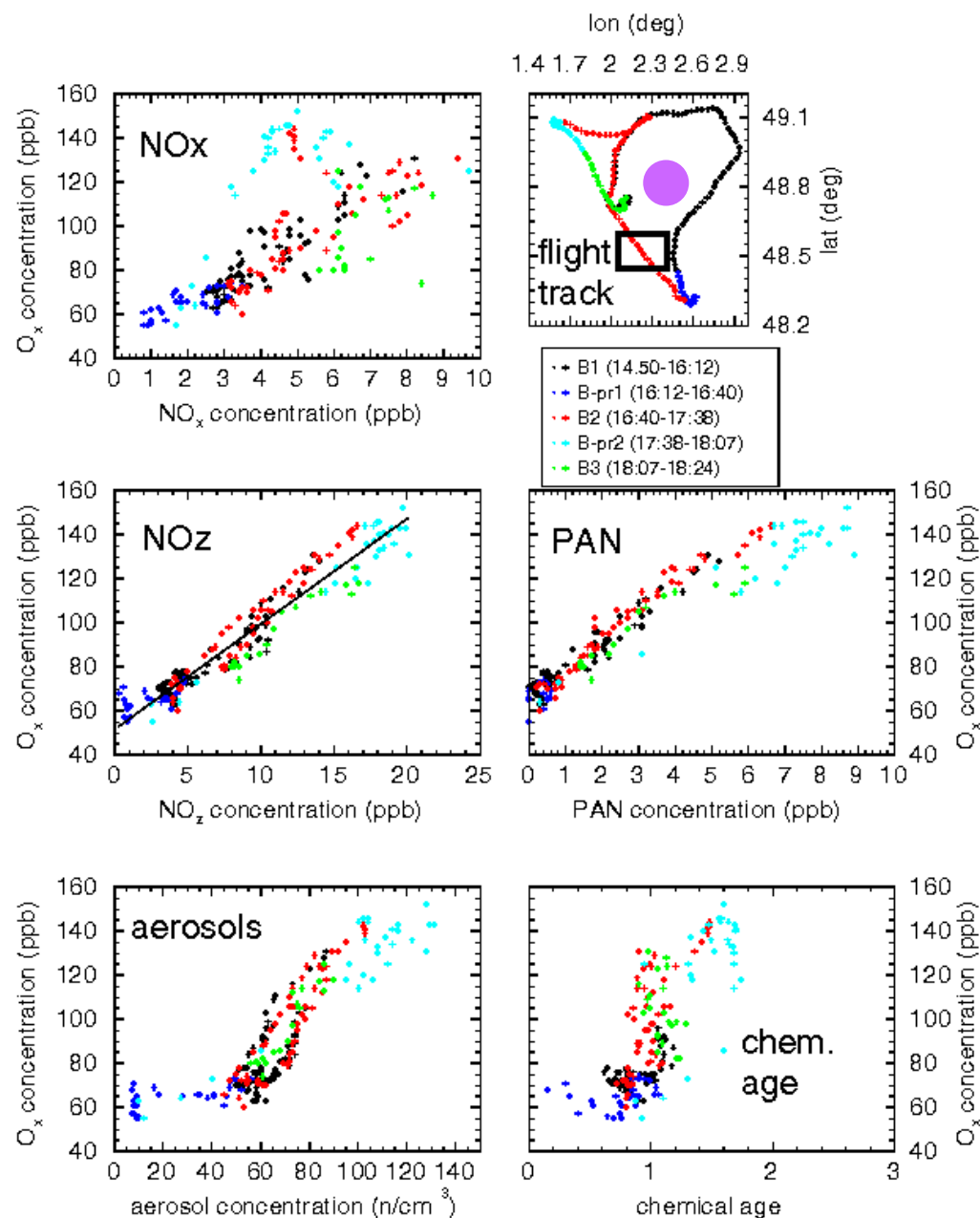
**Air Quality at  
Paris/France,  
17/7/99  
14:50-18:24**

**Ozone concentration  
and wind vectors  
at altitudes less than  
1000m**

**as measured by  
MetAir's Dimona aircraft  
during the ESQUIF-99  
campaign**

**MetAir**

## Correlations between O<sub>x</sub> and various species



**Air Quality at  
Paris/France,  
17/7/99  
14:50-18:24**

**NO<sub>x</sub>, NO<sub>z</sub>, PAN, aerosols  
and chemical age of  
pollutants  
at altitudes less than  
1000m**

**as measured by  
MetAir's Dimona aircraft  
during the ESQUIF-99  
campaign**

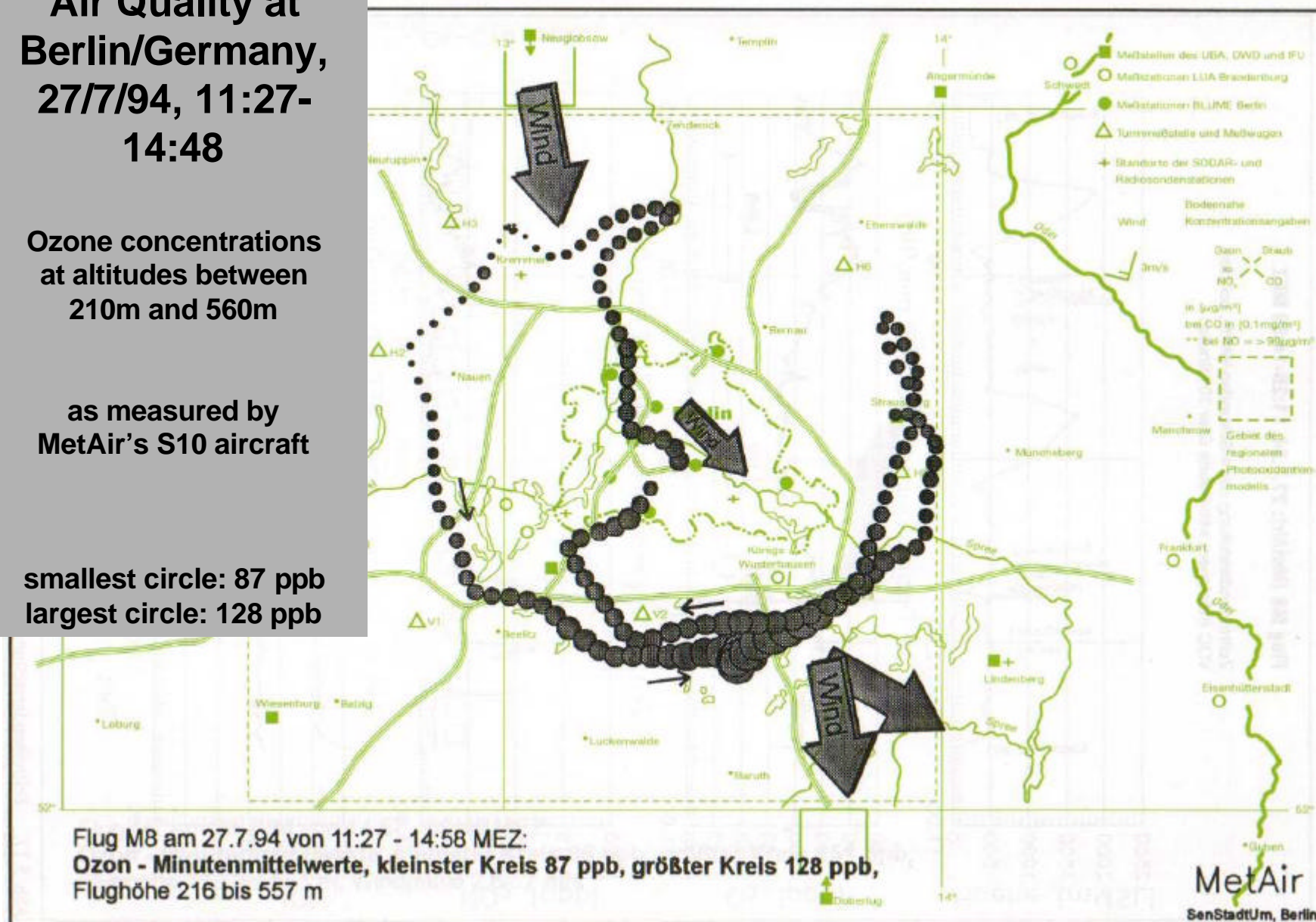
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# Air Quality at Berlin/Germany, 27/7/94, 11:27- 14:48

Ozone concentrations  
at altitudes between  
210m and 560m

as measured by  
MetAir's S10 aircraft

smallest circle: 87 ppb  
largest circle: 128 ppb



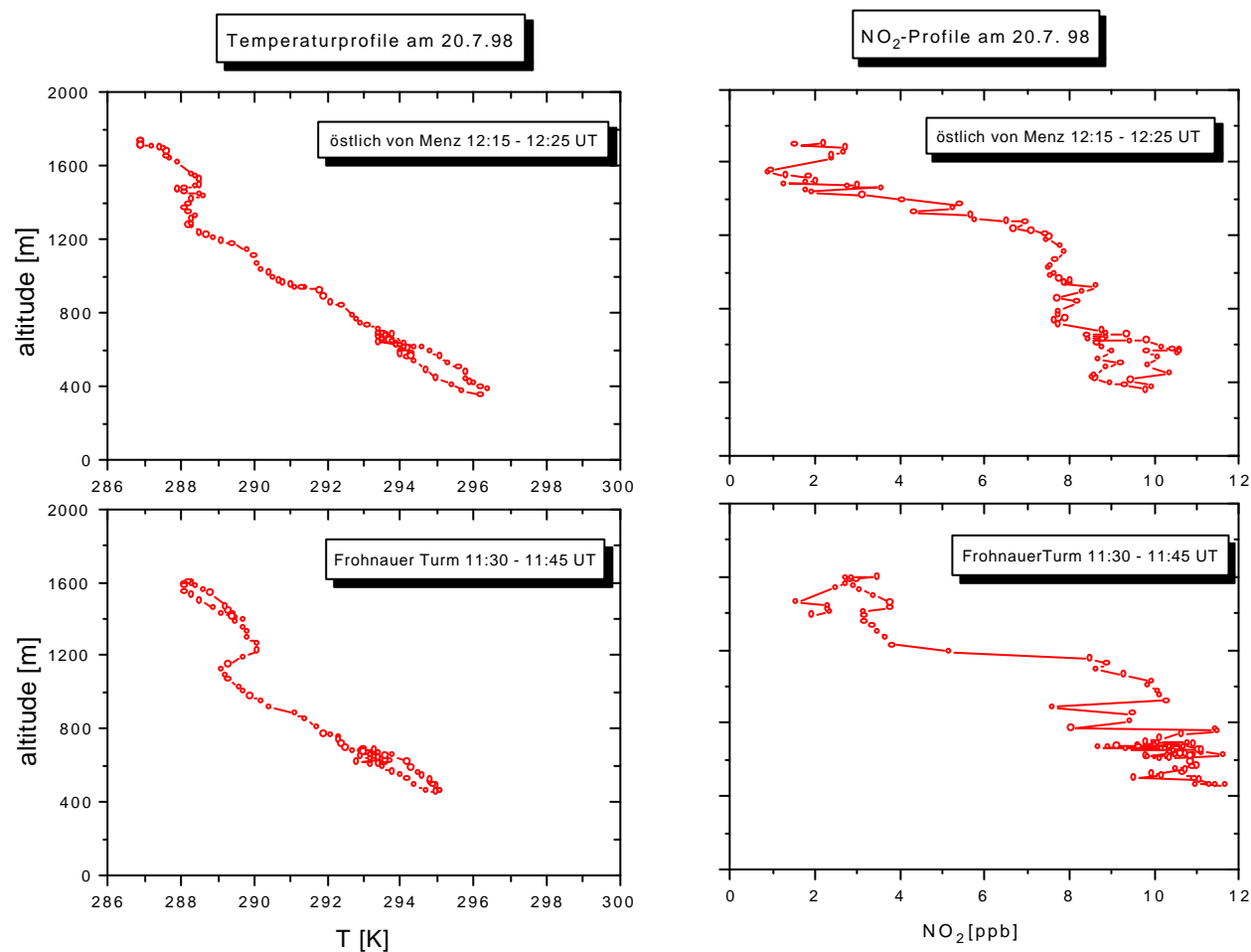
# Temperature and NO<sub>2</sub> profiles of an airmass which has passed over the city of Berlin (BERLIOZ campaign 1998)

as measured by MetAir's S10 aircraft

Bottom diagrams: near the edge of the city

Top diagrams: same airmass 50km further downwind over open country

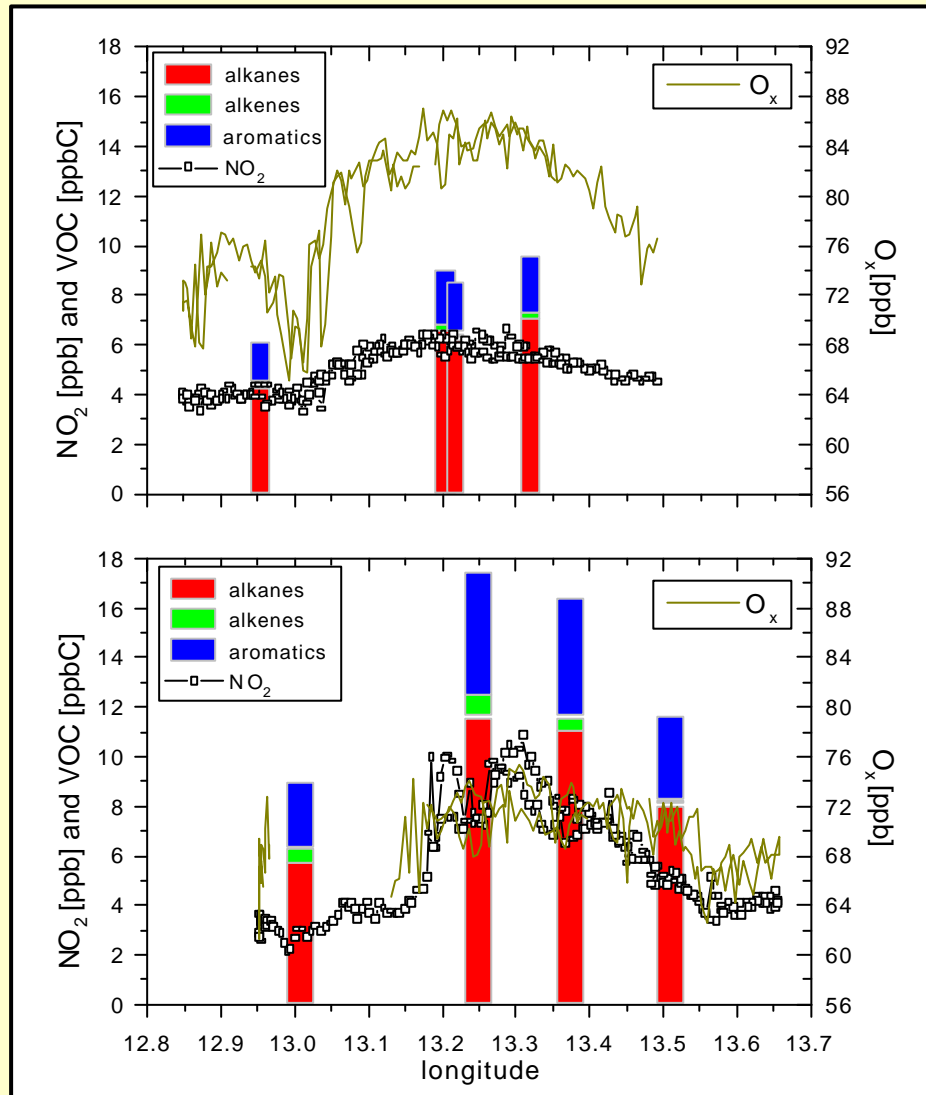
(note the lower inversion level and the vertical mixing of the NO<sub>2</sub>)



**NO<sub>2</sub>, O<sub>x</sub> and VOC in 600 m altitude, 20.7. 98**

lower picture: at north outskirts of Berlin, 10:18 -10:47 UT

upper picture: 50 km away from lower picture, 13:08 - 13:30 UT



## Air Quality at Berlin/Germany, 20/7/98

Ox, NO<sub>2</sub> and VOCs  
at 600m altitudes near the  
downwind edge of the city  
(lower panel)  
and 50km further  
downwind  
(upper panel)

as measured by  
the Airmotec GC flown in  
MetAir's S10 aircraft  
during the BERLIOZ-98  
campaign

## Advantages of the SERA concept

- ➔ Focus on science and the application rather than on the platform
- ➔ Extremely cost-efficient, often an order of magnitude less expensive than “traditional” platforms
- ➔ Operationally often much safer than using “traditional” methods (parachute recovery system, modern much stronger airframe, fewer occupants, much less weight)
- ➔ Very high resolution measurements due to slow flying speed
- ➔ Measurements in “confined” or difficult areas such as valleys, over populated areas, close to source, very low altitude



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## **Advantages of the SERA concept (cont'd)**

- ✈ **Environmentally friendly technology (exhaust/noise from two 500hp “old” engines compared with exhaust/noise from one 100hp modern engine)**
- ✈ **Much more flexible than using unmanned aircraft (UAVs), also much less expensive, fewer operational restrictions**
- ✈ **“Aircraft-in-a-Box” concept for uncomplicated and rapid deployment worldwide**



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*“Small is beautiful”*



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